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1. Your reference

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3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Loughborough University Innovations Limited
Ashby Road
Loughborough
Leicestershire
LE11 3TU

Patents ADP number *(if you know it)*

7001829001

If the applicant is a corporate body, give the country/state of its incorporation

GB

4. Title of the invention

Direct Tyre Retreading

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

McNeight & Lawrence
Regent House
Heaton Lane
Stockport
Cheshire
SK4 1BS

Patents ADP number *(if you know it)*

0001115001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Claim*(s)*	3
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Signature McNeight & Lawrence

Date 23.07.99

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James A Robertson 0161 480 6394

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DIRECT TYRE RETREADING

The present invention is concerned with apparatus and methods of forming on a surface of an article a moulding from flowable material, and particularly for effecting a retreading of a tyre directly on a tyre casing.

Various methods of tyre retreading are known. Two particularly widely used techniques are Cold Capping and Hot Capping. In cold capping a precured (i.e. vulcanised) tread having a surface pattern is applied to a prepared tyre casing (i.e. a tyre which has been machined down to a predetermined size and any irregularities, e.g. pits or hollows, repaired) with a layer of uncured cushioning rubber separating the two. The arrangement of tyre tread, rubber cushioning and tyre casing held together in a tyre press is then autoclaved, curing (i.e. vulcanising/cross-linking) the cushioning rubber and bonding the tyre casing and tread. In hot capping a tread (having no surface pattern) is extruded (i.e. is un-cured), is applied to a prepared tyre casing and the tyre casing and tread is then moulded in a heated tyre press to form a tread pattern and to cure the tread, bonding it to the tyre casing.

Each technique has its advantages and disadvantages - cold capping enables a retreader to minimise capital investment by purchasing precured treads from suppliers, whereas hot capping requires greater capital investment but reduces the cost of consumables by not requiring the purchase of precured treads.

In both cases the predominant process cost is the time taken to heat the rubber in a tyre press to effect curing, which effectively determines the number of tyres which can be retreaded per tyre press per hour - heat must be conducted through a rubber layer about 20 mm thick to raise the temperature (typically from less than 80 °C) to about 160 °C, which is a slow process since rubber is an extremely good insulator.

This means that a typical curing time (for either process) is 60-90 minutes.

Retreading effected by moulding directly onto the surface of a tyre casing is known from e.g. US 4583928 and US 4139592, neither of which appears to have been commercially developed. Each of these requires the use of separate injection points in the crown (i.e. the equatorial plane) of the tyre tread mould. Effecting injection in the crown of the mould can be difficult and may require expensive machinery. Use of such methods may be achieved by e.g. sequential injection into each injection point (as opposed to simultaneous injection). This however would typically require a potentially time-consuming indexing of the tyre in order that injection points are presented in turn to an injection machine nozzle. This would also provide the potential for the formation of weak interfaces between the individually injected volumes of rubber. The provision of machinery for the simultaneous injection of rubber into the mould from crown injection points may be particularly expensive to achieve and operate. In particular, US 4583928 requires that a series of arcuate sections of a tyre casing have mouldings formed on them, one after the other, each moulding being cured before the next is made. This is particularly slow and provides a series of potentially weak weld lines. US 4139592 allows for the simultaneous use of a series of injectin ports locates across the equatorial plane of a moulding cavity to form a tread on a tyre casing. The specific positioning (on the equatorial plane) of the injection ports and their relative position forms an essential element of the invention, preventing the formation of weak weld lines. Curing advantageously takes place while the tyre is still in the injecvtion mould (column 6 lines 20-27).

The present invention overcomes the prior art disadvantages, allowing for tread formation directly on a tyre casing, reducing the effort required in preparing tyre casings, and reducing the time required for curing. Advantageously, curing can take place separately from the tread forming apparatus (below), allowing optimum usage of

the tread forming apparatus and helping to reduce the capital investment per tyre retreaded per hour.

According to the present invention there is provided a method of forming on a surface of an article a moulding from flowable material comprising the steps of:

i) Contacting the surface with a mobile mould matrix and material inlet to form a moulding cavity defining a first volume, the material inlet being displaceable relative to the surface and the mobile mould matrix;

ii) Filling the moulding cavity via the material inlet with flowable material;

iii) Stopping filling and displacing the material inlet relative to the mobile mould matrix and the surface to leave exposed flowable material, the flow of material from the material inlet into the moulding cavity being severed;

iv) Contacting the exposed flowable material, the mobile mould matrix and the surface with a forming member to form a moulding cavity defining a second volume; and

v) Curing the flowable material to complete the moulding.

The material inlet and forming member may define a side wall of the moulding cavity. In the case of cylindrical or toroidal articles, this would not be an equatorial plane such as a tyre surface.

The filling of the mould cavity of step (ii) may be effected simultaneously about the circumference (i.e. the perimeter) of the article. The provision of simultaneous

injection minimises the potential for formation of weak interfaces. Forming is completed by step (iv).

As discussed above, the curing of flowable materials such as rubber can be a slow and time-consuming process which significantly affects the economics of a manufacturing process. By displacing the material inlet from the mobile mould matrix and the surface and replacing it with a forming member, the material inlet (and the system which supplies flowable material to it) is free to be used in another moulding process whilst curing takes place. Since the material inlet and the material supply system connected to it comprise typically the most expensive part of the apparatus used in the moulding process, this can lead to a very substantial reduction in the cost of apparatus required per moulding produced per hour. It also means that as soon as the moulding cavity has been filled and the material inlet replaced by the forming member, the flowable material can be cured, avoiding unnecessary cooling.

Displacement of the material inlet relative to the mobile mould matrix causes a break in the flowable material linking them. This may be aided by the use of a cutting tool. The exposed flowable material of step (iii) may be manipulated prior to contacting it with the forming member. For example, exposed rubber could be rolled down to contact an exposed surface of a tyre casing.

The article on whose surface the moulding is to be formed may be of any desired shape, and similarly the mobile mould matrix, material inlet and forming member may be appropriately shaped.

The invention, however, is particularly useful in forming mouldings as annular layers on toroidal or cylindrical cores. In particular, the invention may be used for moulding tyre treads onto tyre casings.

The flowable material may be any material which can be made to flow into the moulding cavity, for example materials such as rubbers or thermoplastics in the melt state, thermosetting resins such as polyurethane in the melt state, or particulate materials which are able to flow. Clearly, when the material inlet is displaced the flowable material at the inlet should be in a sufficiently viscous state to prevent its escape.

By forming the moulding directly onto the surface of the article (e.g. a tyre casing) rather than producing the moulding separately and then attaching it to the surface of the article by curing (e.g. hot capping or cold capping), the process time can be reduced significantly. The separation of the curing step from the moulding step means that a number of mouldings can be simultaneously cured.

The material inlet may be shaped so that at the point at which material enters the moulding cavity, it has a reduced cross-section. This causes the rate of flow per unit area to be greater than that in the rest of the material inlet, generating deformation energy and heating the flowable material as it enters the moulding cavity. This forms a further aspect of the present invention. Thus according to the present invention there is also provided injection moulding apparatus for flowable settable material in which work done on the flowable material causes its temperature to be elevated sufficiently to set it (i.e. cure it). The work done on the flowable material may be by injection force against flow resistance.

The elevated temperature of the flowable material at the start of the curing process results in a shorter curing process time and may additionally improve the performance and wear life of the moulding (e.g. tyre tread) - high temperatures are conducive to oxidative degradation and so the longer that the surface layer of the moulding is held at a high temperature, the more oxidative degradation will occur, and *vice versa*.

The rate of flow of material through the material inlet may be varied as the moulding cavity is filled. For example, it may be reduced for the final material to enter the moulding cavity. This can be used to prevent excessive heating and curing (crosslinking) of residual material in the material inlet, particularly between cycles.

Rather than introduce a measured volume of material into the moulding cavity, a pressure sensor (e.g. transducer) or pressure switch may be used to determine the pressure being placed upon the flowable material and to stop filling of the moulding cavity when a predetermined level of pressure is reached. This is particularly useful since it means that a variable volume of material may be introduced to the moulding cavity to fill it - in the case of tyre casings, this means that their surface need not be uniform and may e.g. contain pits or hollows. This tolerance of flaws in the surface of the tyre casing can reduce the cost of preparing a tyre casing for retreading and may also allow tyre casings to be retreaded which, due to surface deformation, would not be suitable for retreading using existing techniques such as hot or cold capping.

The material inlet may form a side of the moulding cavity. In the case of the article being a tyre casing, the material inlet may form a tyre-edge side of the moulding cavity.

Thus the material inlet may have e.g. an overall radial shape, allowing filling from all around an article such as a tyre casing. Since a tyre tread will have a patterned outer (circumferential) surface, this provides the advantage that displacing of the material inlet will not affect the patterned surface being formed.

Also provided according to the present invention are apparatus for forming on a surface of an article a moulding from flowable material, comprising a mobile mould matrix, material inlet and forming member, the material inlet being displaceable relative to the mobile mould matrix and the article.

The apparatus may additionally comprise at least one support member for the article - in the case of forming a tread on a tyre casing, the pressures required to form the moulding would cause deformation of the tyre casing and so the provision of a support member (or support members) prevents any deformation from occurring.

The material inlet may additionally comprise a material injection system, for example comprising a screw pre-plasticisation unit into which is fed the flowable material in the solid state, the plasticised flowable material being forced into an injection cylinder from where a hydraulic injection ram actuator exerts force on it, causing it to fill the moulding cavity. The injection cylinder may be heated.

It may be desirable to be able to use the material injection system to form a range of mouldings, e.g. different tyre treads on different sized tyre casings, using a range of mobile mould matrixs and material inlets. Thus the material inlet may be removably attached to the material injection system.

The forces required to cause the flowable material to fill the moulding cavity and to subsequently form the moulding may be quite substantial - in the case of retreading a tyre casing using a rubber, a maximum force of about 12 MPa, and an average force of about 4.5 MPa, has to be exerted upon the material. Thus the mobile mould matrix must be capable of withstanding such forces - each quadrant of a mobile mould matrix and forming member used to exert 4.4 MPa of pressure in forming a tyre tread on a tyre casing will have approximately 98 tonne of opening pressure force exerted upon it.

The mobile mould matrix may comprise a segmented mould which is joined together to define the inner shape of the mobile mould matrix, i.e. that which will define the moulding cavity. A retaining ring may be placed around the segmented mould and a cam or cams attached to allow it manipulation. A support assembly may also be used

to provide mechanical support for the mobile mould matrix, particularly for holding the edge forming member in place and exerting sufficient force upon it.

Despite the teachings of the prior art such as US 4139582 which states that in order to successfully fill a moulding cavity defined about a tyre casing, injection of rubber must be from the equatorial plane of the moudling cavity, the present inventors have now found that, surprisingly, injection of flowable materials into a tyre casing or other cylindrical or toroidal moulding cavity may be effected from the side of the moulding cavity. The inventors have found that this need not result in the formation of weak weld lines and thus the products of such moulding operations are mechanically sound.

Thus the present invention also provides a method of forming from flowable material a moulding on a surface of a toroidal or cylindrical article having at least one side wall, comprising the steps of:

i) contacting the surface with a mobile mould matrix having either one continuous inlet on the side wall or a plurality of discontinuous inlets along the length of the side wall, and simultaneously contacting the inlet or each of the inlets with an injection port, the mobile mould matrix and the injection ports defining a moulding cavity;

ii) filling the moulding cavity via the inlets with flowable material;

iii) stopping filling and displacing the injection port or each of the injection ports relative to the mobile mould matrix and the surface to leave exposed flowable material, the flow of material from the injection port or injection ports into the moulding cavity being severed;

iv) sealing the inlet or each of the inlets; and

v) curing the flowable material to complete the moulding.

Such a toroidal or cylindrical article could be a tyre casing. The point of injection into the side wall could be anywhere on the side wall.

The invention will be further apparent from the following description, with reference to the several figures of the accompanying drawings, which show, by way of example only, one form of tyre retreading apparatus. Of the figures:

Figure 1 shows cross-sectional views of a mobile mould matrix, material inlet and article (tyre casing) whilst the moulding cavity is being filled ("fill step") (Figure 1a) and when the material inlet is displaced to sever the connection with the moulding cavity ("crop" step) (Figure 1b). Cross-hatched area (also in Figures 4 and 7) indicates the cross-section of circular inlet channel 131;

Figure 2 shows (Figures 2a and 2b) support members forming a support assembly for a tyre casing;

Figure 3 shows the tyre casing support assembly of Figure 2, the tyre casing being contacted by edge forming member and mobile mould matrix;

Figure 4 shows the arrangement of Figure 3, together with a material injection system, a datum/support for the apparatus, and an actuator for controlling filling and displacing the material inlet.

Figures 5 shows (Figures 5A-5C) an alternative material inlet arrangement in use;

iv) sealing the inlet or each of the inlets; and

v) curing the flowable material to complete the moulding.

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Figure 3 shows the tyre casing support assembly of Figure 2, the tyre casing being contacted by edge forming member and mobile mould matrix;

Figure 4 shows the arrangement of Figure 3, together with a material injection system, a datum/support for the apparatus, and an actuator for controlling filling and displacing the material inlet.

Figures 5 shows (Figures 5A-5C) an alternative material inlet arrangement in use;.

Figure 6 shows (Figures 6A and 6B) another alternative material inlet arrangement, having material injection ports; and

Figure 7 shows the embodiment of Figures 5A-5C in use.

Example 1

In a first embodiment (Figures 1-4), moulding apparatus 10 for forming a moulding on the outer surface of tyre casing 20 from rubber 11 comprises support members 30, 31, 32, 33 and 40, 41, 42, 43 for tyre casing 20, support members 30-33, 40-43 being held in place by locking/mounting ring 50. Mobile mould matrix 60 comprises segmented mould 70 having heater elements 80, 81, 82, 83 and retaining ring 90 which holds segmented mould 70. Cams 100, 101 are attached to segmented mould 70 to manipulate it. Material inlet 110 comprises control ring 120 and circumferential inlet 130 having inlet channel 131. Mobile mould matrix 60, casing 20 and material inlet 110 together define moulding cavity 140 having a first volume. Similarly, mobile mould matrix 60 and forming member 230 together define moulding cavity 140 having a second volume. Inlet channel 131 has a reduced cross-sectional area at the point at which rubber 11 will enter moulding cavity 140. The first and second volumes of mould cavity 140 are equal.

Circumferential inlet 130 is removably attached to material injection system 150 which comprises pressure transducers 151, 152, injection cylinder 160 having heater 161, screw pre-plasticisation unit 170 and hydraulic injection ram actuator 180.

Support plate 190 acts as a datum for the apparatus as a whole, ensuring the correct positioning of material inlet 110 and mobile mould matrix 60. Control ring 120 is attached to actuator 200. Forming member 230 contacts mobile mould matrix 60 and has heater elements 220, 221.

In use, a tyre casing 20 is prepared for retreading by inserting support members 30-33 and then support members 40-43. Support members 30-33 widen as the radius increases, and support members 40-43 narrow as the radius increases. Locking/mounting ring 50 is then placed into the orifice defined by support members 30-33 and 40-43, locking them in position and providing means for subsequently mounting tyre casing 20. As can be seen from Figures 2a and 2b, support members 30-33 and 40-43 and locking/mounting ring 50 are arranged to redistribute radially acting forces in the circumferential direction. As can be seen from Figure 4, support members 30-33, 40-43 are arranged to redistribute forces mainly on the side of material inlet 110 where high forces are exerted. Tyre casing 20 is then contacted by mobile mould matrix 60, which is positioned by referencing locking/mounting ring 50 using cams 100, 101. The use of cams 100,101 in bringing together mobile mould matrix 60 and material injection system 150 results in the edge of inlet 130 contacting casing 20 and the force exerted being transmitted across casing 20 to press the edge of mould 70 against casing 20. Thus a positive sealing force is exerted against the rubber pressure without affecting any other aspect of the filling operation.

Whilst this is being done, material injection system 150 and inlet channel 131 are charged with rubber 11 ready for supply to moulding cavity 140 when it has been formed. Actuator 200 positions control ring 120 over inlet channel 131 to prevent escape of rubber 11, pre-plastication unit 170 is activated and rubber 11 in the solid state is fed into it. The deformation energy exerted upon solid rubber 11 is converted into heat, sufficient to change the rubber 11 into a plastic/melt state. As the material injection system 150 and inlet channel 131 fills with rubber 11, air is vented and injection ram actuator 180 exerts a small back pressure and is forced back (i.e. is retracted) by rubber 11. Once ram actuator 180 has been fully retracted and the pressure detected by transducers 151, 152 has reached a predetermined level, material injection system 150 and material inlet 131 are charged and ready to fill moulding cavity 140. Rubber 11 is kept in the plastic/melt state by heater 161.

The assembly of tyre casing 20 and mobile mould matrix 60 is then contacted with material inlet 110, control ring 120 being simultaneously retracted by actuator 200 and opening inlet channel 131, thus defining moulding cavity 140. Material inlet 110 is connected to material injection system 150, which also contacts locking/mounting ring 50 to ensure correct positioning of tyre casing 20 and mobile mould matrix 60 relative to material inlet 110.

Ram actuator 180 then forces rubber 11 out of material injection system 150, through inlet channel 131 and into moulding cavity 140. Flow resistance caused by the reduced cross-section part of inlet channel 131 causes deformation energy to be generated, heating rubber 11 as it enters moulding cavity 140. Heaters 80, 81, 82, 83 heat mobile mould matrix 60 and moulding cavity 140. Once ram actuator 180 has been extended by at least a first predetermined amount, meaning that about 0.5 litres of rubber is needed to complete filling, the rate of extension of ram actuator 180 is reduced in order to reduce the heating of the final rubber 11 to enter moulding cavity 140. Once ram actuator 180 has been extended by at least a second predetermined amount and transducers 151, 152 detect a pressure of at least a predetermined amount, moulding cavity 140 has been filled with rubber 11. Actuator 200 is then extended, causing control ring 120 to lift mobile mould matrix 60 away from circumferential inlet 130 and simultaneously closing inlet channel 131, severing the flow of rubber from material inlet 110 (i.e. circumferential inlet 130) into moulding cavity 140. Cams 100, 101 then displace material inlet 110 relative to mobile mould matrix 60 and the outer surface of tyre casing 20, leaving exposed rubber 11.

Inlet channel 131 and material injection system 150 may once again be charged with rubber 11.

Mobile mould matrix 60 and the outer surface of tyre casing 20 are then contacted with forming member 230 to form moulding cavity 140 defining a second volume and causing the exposed rubber 11 to contact the outer surface of tyre casing 20.

The rubber 11 is then cured by heating it using heaters 231, 232, 80-83. Forming (shaping) has already been completed.

Example 2

In a second embodiment (Figures 5A-5C, 7), a more robust and mechanically simpler apparatus is provided. The use of the apparatus is extemely similar to that of the previous embodiment. Notably, control ring 120, support plate 190 and actuator 200 do not form part of the second embodiment. Control ring 120 is replaced by an extended circumferential inlet 130, which additionally comprises high temperature thermoplastic seal 300. Heater 161 and transducers 151, 152 are not shown.

In use, the tyre casing 20 is prepared for retreading as before with support members 30-33, 40-43 and locking/mounting ring 50. Mobile mould matrix 60 is placed around casing 20. The inlet apparatus differs significantly from those of Figure 1, not having control ring 120 and related actuating and supporting means, simplifying the apparatus significantly. Inlet 130 is extended in size, obviating the need for control ring 120. Inlet 130 is also provided with high temperature thermoplastic seal 300 which is slightly deformable (without affecting the surface of the tyre tread to be formed) and ensures a sealing of mould cavity 140 whilst making the sealing a more mechanically tolerant process. Material inlet 110 and mobile mould matrix 60 are mounted on tyre casing 20 to define mould cavity 140. Mould cavity 140 is then filled as before with rubber 11 through circumferential inlet channel 131. Material inletr 110 is then displaced relative to casing 20 and mobile mould matrix 60 to leave exposed flowable material, the rubber 11 connecting that attached to tyre casing 20 and that in inlet channel 131 simply tearing as it is stretched.

Mobile mould matrix 60 and the outer surface of tyre casing 20 are then contacted with forming member 230 to form moulding cavity 140 defining a second volume. In order to prevent deformation of rubber 11 resulting from expansion of volatiles in rubber 11 this should be done within two minutes (preferably less) from the removal of material inlet 110. The rubber 11 is then cured by heating it using heaters 231, 232, 80-83. Forming (shaping) has already been completed. Whilst this forming and curing step takes place, material inlet 110 can be used in a subsequent retreading process with a different tyre casing 20 and mobile mould matrix 60.

Example 3

In a third embodiment (Figures 6A-6B), rather than use a circumferential inlet channel 131, a series of 12 injection ports 401-412 are used to simultaneously inject rubber 11 into moulding cavity 140 through inlets 421-432. The method of operation is exactly the same as for Example 2, except that upon removel of intection ports 401-412 from inlets 421-432 of mobile mould matrix 60, inlets 421-432 are then filled with sealing plugs 441-452. Rubber 11 is then cured.

Inlet channel 131 actually comprises circular distribution channel 460 to which rubber 11 is fed from injection cylinder 100 by radial feed channels 461-464.

It will be appreciated that it is not intended to limit the invention to the above example only, many variations, such as might readily occur to one skilled in the art, being possible, without departing from the scope thereof as defined by the appended claims.

CLAIMS

1. A method of forming on a surface of an article a moulding from flowable material comprising the steps of:

i) Contacting the surface with a mobile mould matrix and material inlet to form a moulding cavity defining a first volume, the material inlet being displaceable relative to the surface and the mobile mould matrix;

ii) Filling the moulding cavity via the material inlet with flowable material;

iii) Stopping filling and displacing the material inlet relative to the mobile mould matrix and the surface to leave exposed flowable material, the flow of material from the material inlet into the moulding cavity being severed;

iv) Contacting the exposed flowable material, the mobile mould matrix and the surface with a forming member to form a moulding cavity defining a second volume; and

v) Curing the flowable material to complete the moulding.

2. A method according to claim 1, the surface of the article having a cylindrical or toroidal shape.

3. A method according to claims 1 or 2 the article being a tyre casing.

4. A method according to any one of the preceding claims, the flowable material being a rubber or thermoplastic in the melt state or a thermosetting resin in the melt state or a particulate material.

5. A method according to any one of the preceding claims, the material inlet having a reduced cross-section at the point at which material enters the moulding cavity.

6. A method according to any one of the preceding claims, the rate of flow of material into the moulding cavity being varied.

7. A method according to claims 6, the rate of flow of material into the moulding cavity being reduced prior to filling being stopped.

8. A method according to any one of the preceding claims, filling being stopped when the level of pressure upon the flowable material reaches a predetermined level.

9. A method according to any one of the preceding claims, the material inlet forming a side of the moulding cavity.

10. A method according to claim 9, the article being a tyre casing and the material inlet forming a tyre-edge side of the moulding.

11. Apparatus for forming on a surface of an article a moulding from flowable material, comprising a mobile mould matrix, material inlet and forming member, the material inlet being displaceable relative to the mobile mould matrix and the article.

12. Apparatus according to claim 11 additionally comprising at least one support member for the article.

13. Apparatus according to either one of claims 11 or 12, the material inlet additionally comprising a material injection system.

14. A method of forming from flowable material a moulding on a surface of a toroidal or cylindrical article having at least one side wall, comprising the steps of:

i) contacting the surface with a mobile mould matrix having either one continuous inlet on the side wall or a plurality of discontinuous inlets along the length of the side wall, and simultaneously contacting the inlet or each of the inlets with an injection port, the mobile mould matrix and the injection ports defining a moulding cavity;

ii) filling the moulding cavity via the inlets with flowable material;

iii) stopping filling and displacing the injection port or each of the injection ports relative to the mobile mould matrix and the surface to leave exposed flowable material, the flow of material from the injection port or injection ports into the moulding cavity being severed;

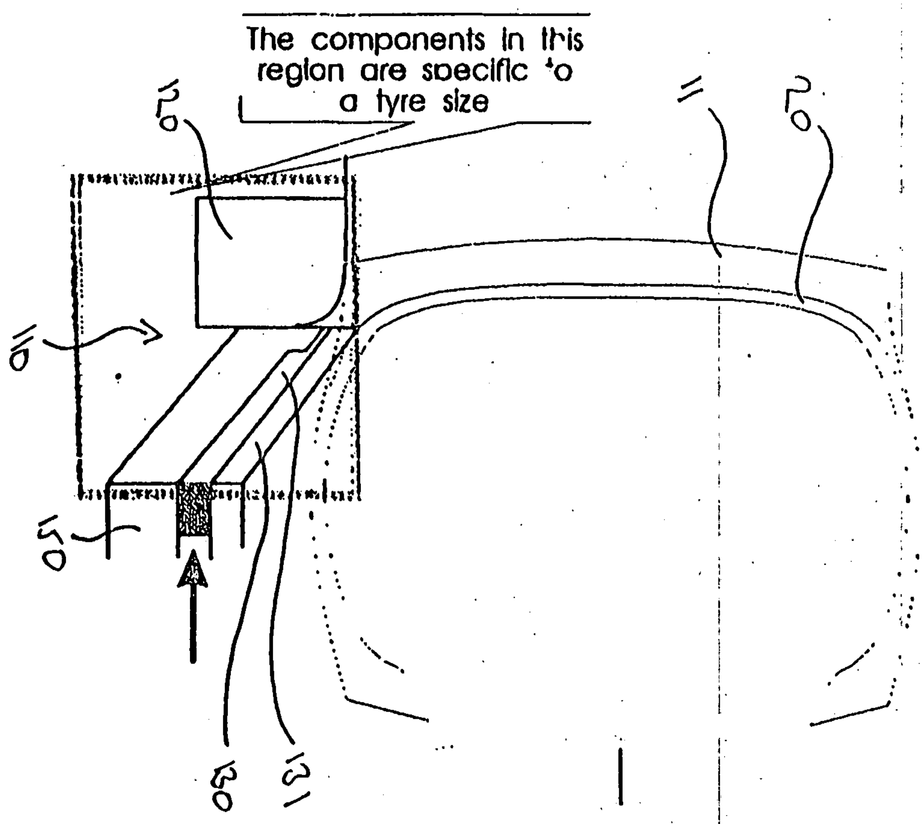
iv) sealing the inlet or each of the inlets; and

v) curing the flowable material to complete the moulding.

RuPEC RETREAD SYSTEM

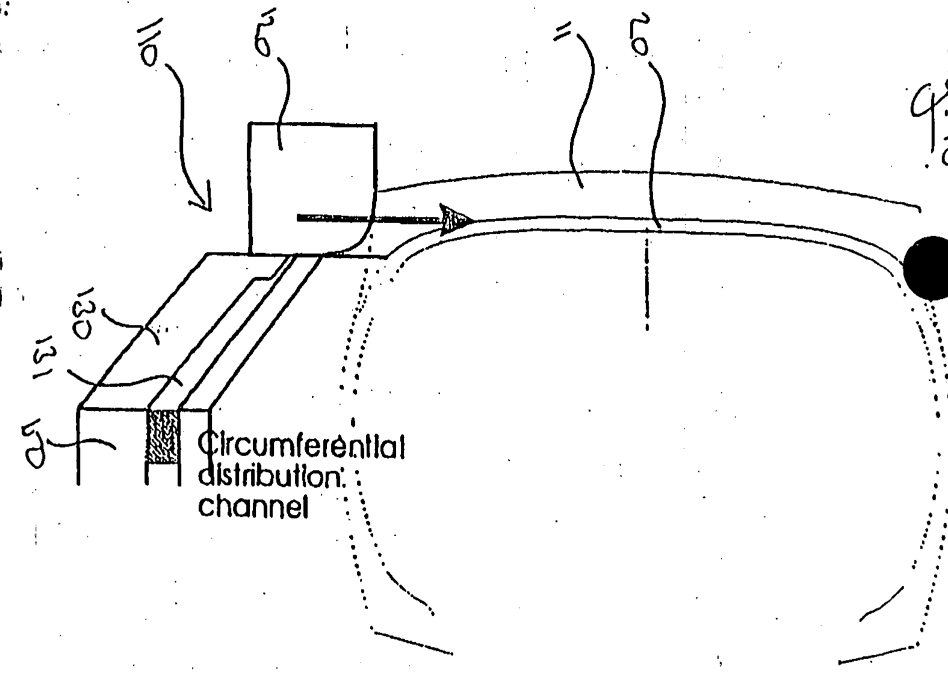
Each tyre size will require its own drum (to support the casing during tread forming & subsequent curing) and matrix. This is also true of current methods but for the system proposed here the drum will have to be more rigid to withstand the tread form filling press

Fig. 1a



FILL

Fig. 1b

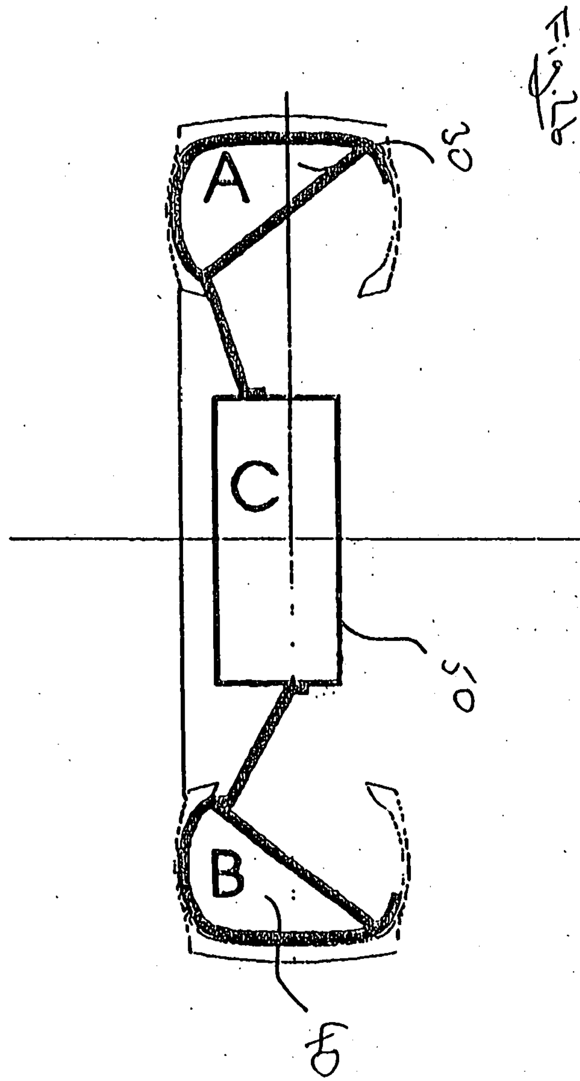


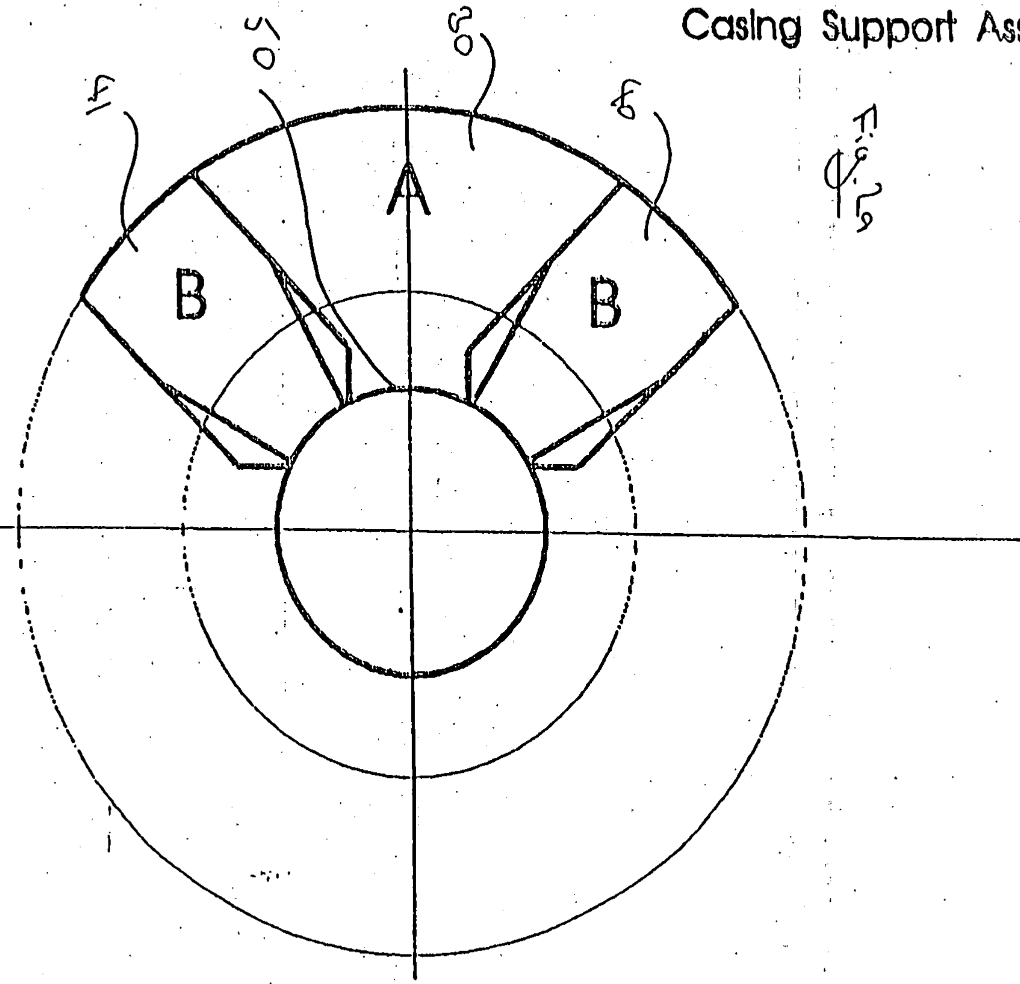
CROP

P. K. Freakley, Loughborough University, 9.2.98

RuPEC RETREAT SYSTE

Casing Support Assembly





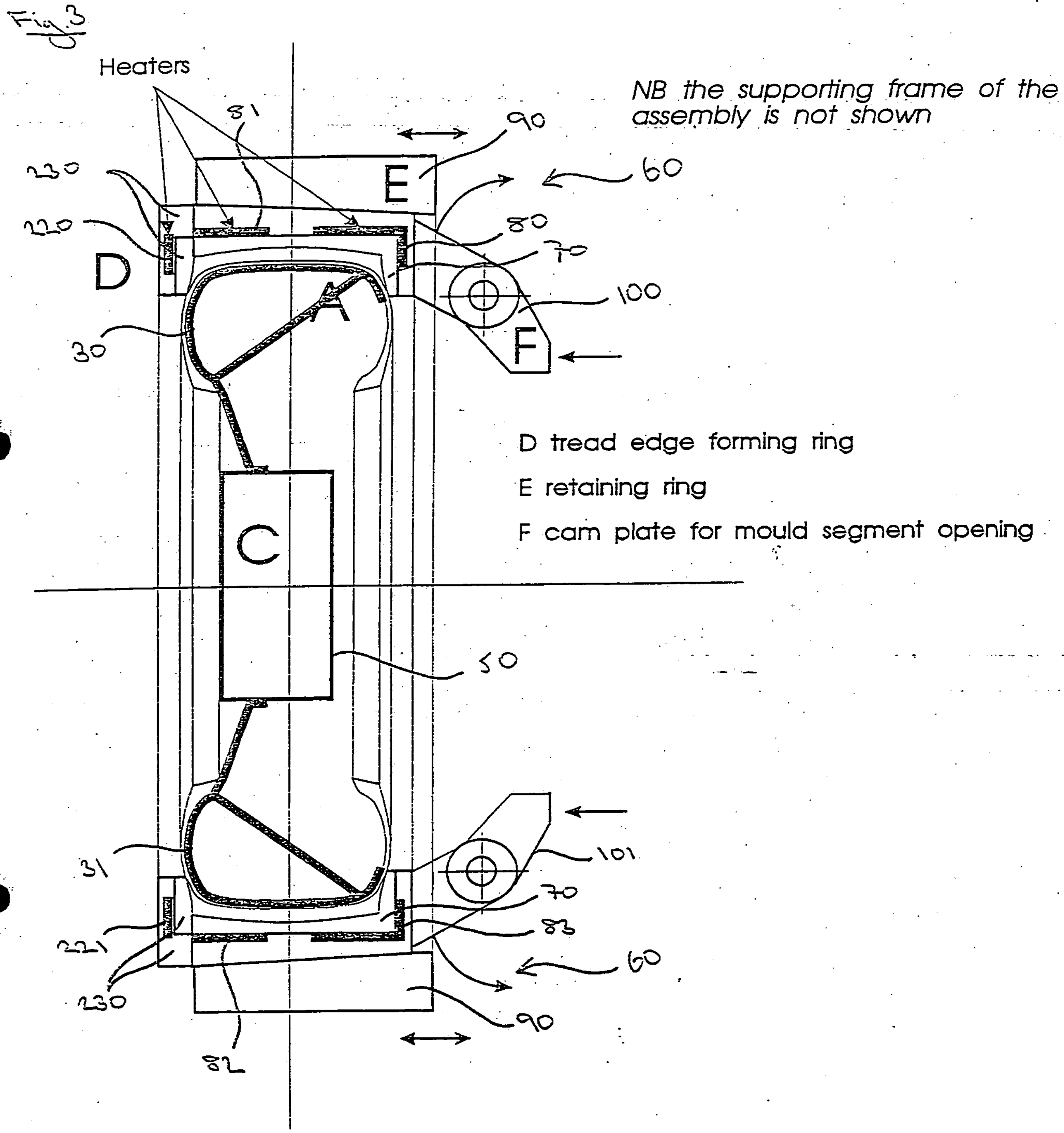
It may be necessary to place th casing supports A & position and then assemble onto the locking/mountin ring C - to give adequate space to manoeuvre them.

It would also make assembly easier if the junction bet the supports A & B is tapered, so that B narrows as its radius increases and A widens correspondingly.

P. K. Fr akley, Loughborough Un'versity, 16.2.98

RuPEC RETREAD SYSTEM

Mobile Mould Matrix & Casing Support Assembly



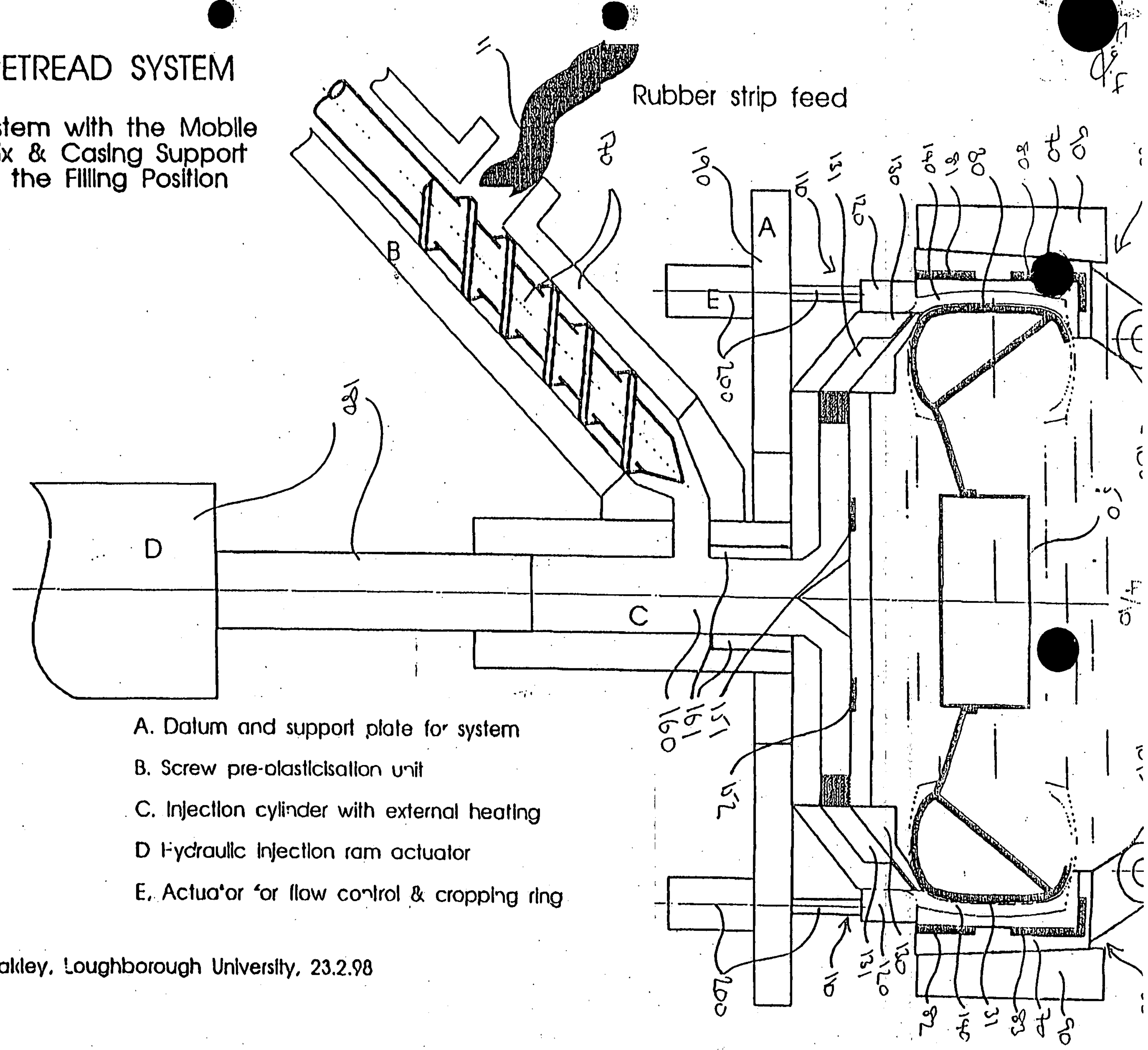
At 4.4 MPa pressure in the mould form, there will be approx 98 tonne opening force on each quadrant of the matrix. A complete circle retaining ring is essential.

To reduce cost and weight, all the actuators for assembly and locking of the mould matrix and casing support assembly could be fitted to the work stations and simple mechanical devices used to maintain clamping, etc.

P. K. Freakley, Loughborough University, 16.2.98

RuPEC RETREAD SYSTEM

Injection System with the Mobile
Mould Matrix & Casing Support
Assembly in the Filling Position



A. Datum and support plate for system

B. Screw pre-plasticisation unit

C. Injection cylinder with external heating

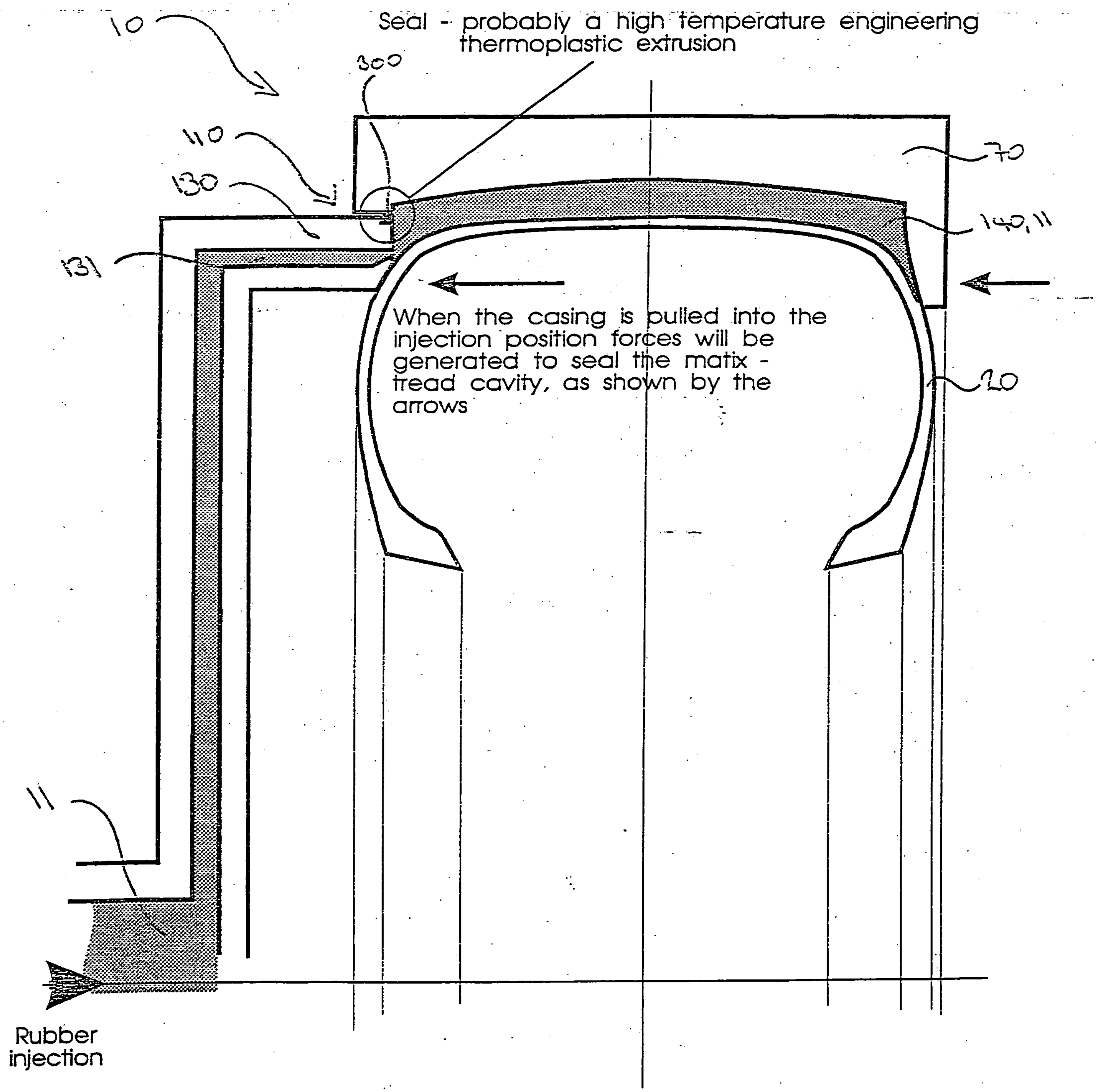
D Hydraulic injection ram actuator

E. Actuator for flow control & cropping ring

P. K. Freakley, Loughborough University, 23.2.98

RuPEC RETREAD SYSTEM (ALT 4)

Fig. 5A



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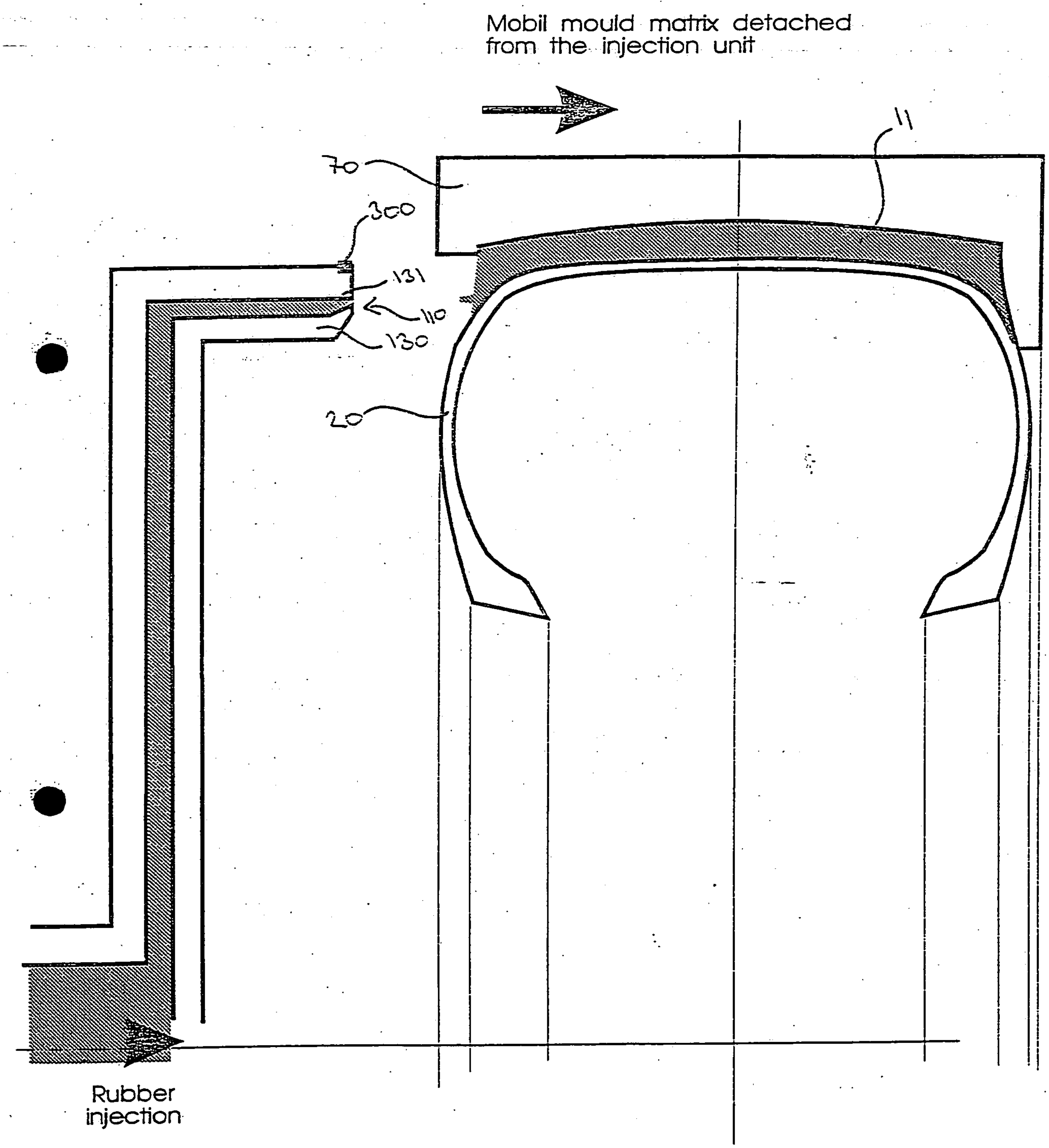
RuPEC RETREAD SYSTEM (ALT 4)

Fig. 5B



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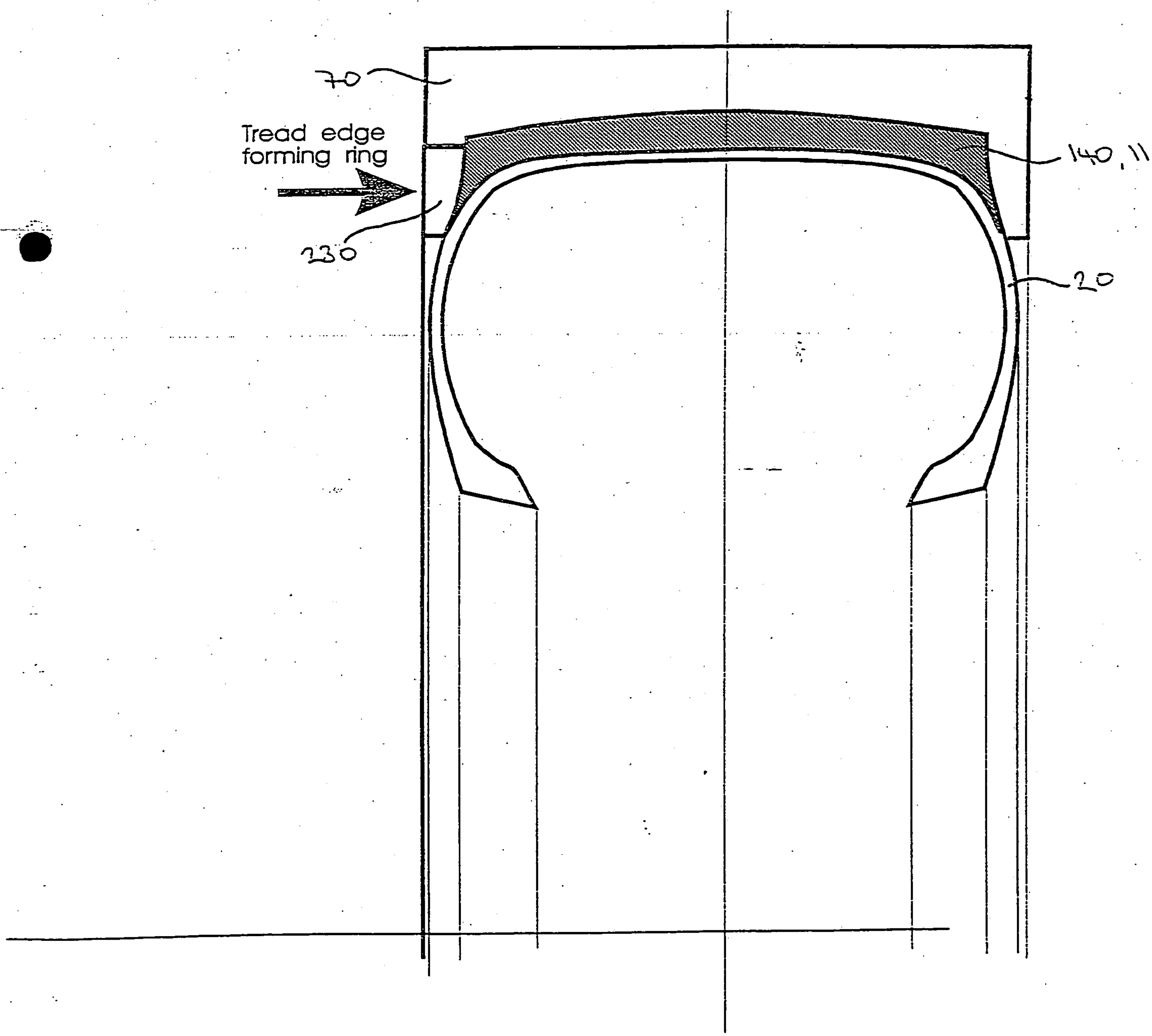
RuPEC RETREAD SYSTEM (ALT 4)

Fig. 5C

Mobil mould matrix detached
from the injection unit



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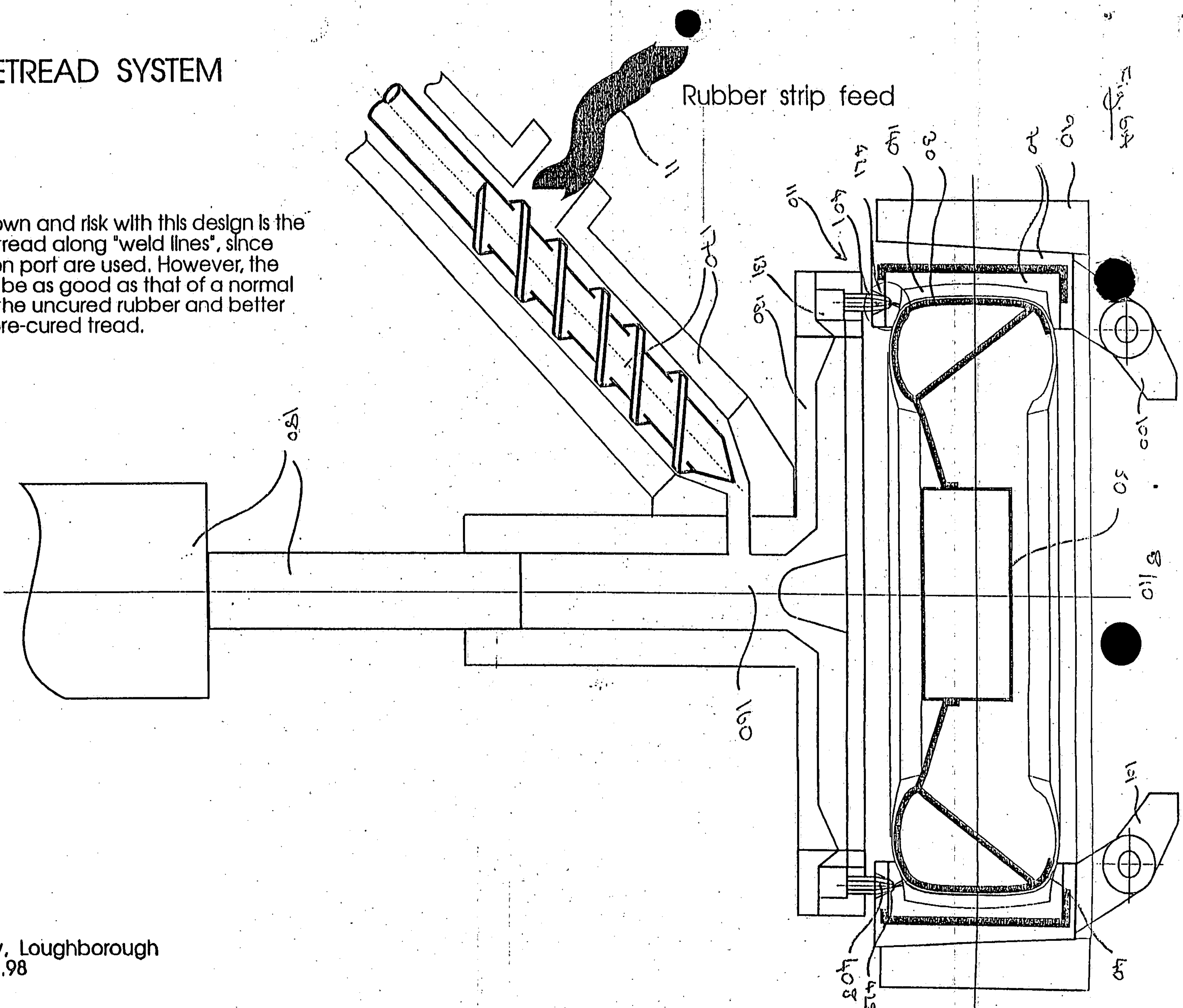
RuPEC RETREAD SYSTEM (ALT 1)

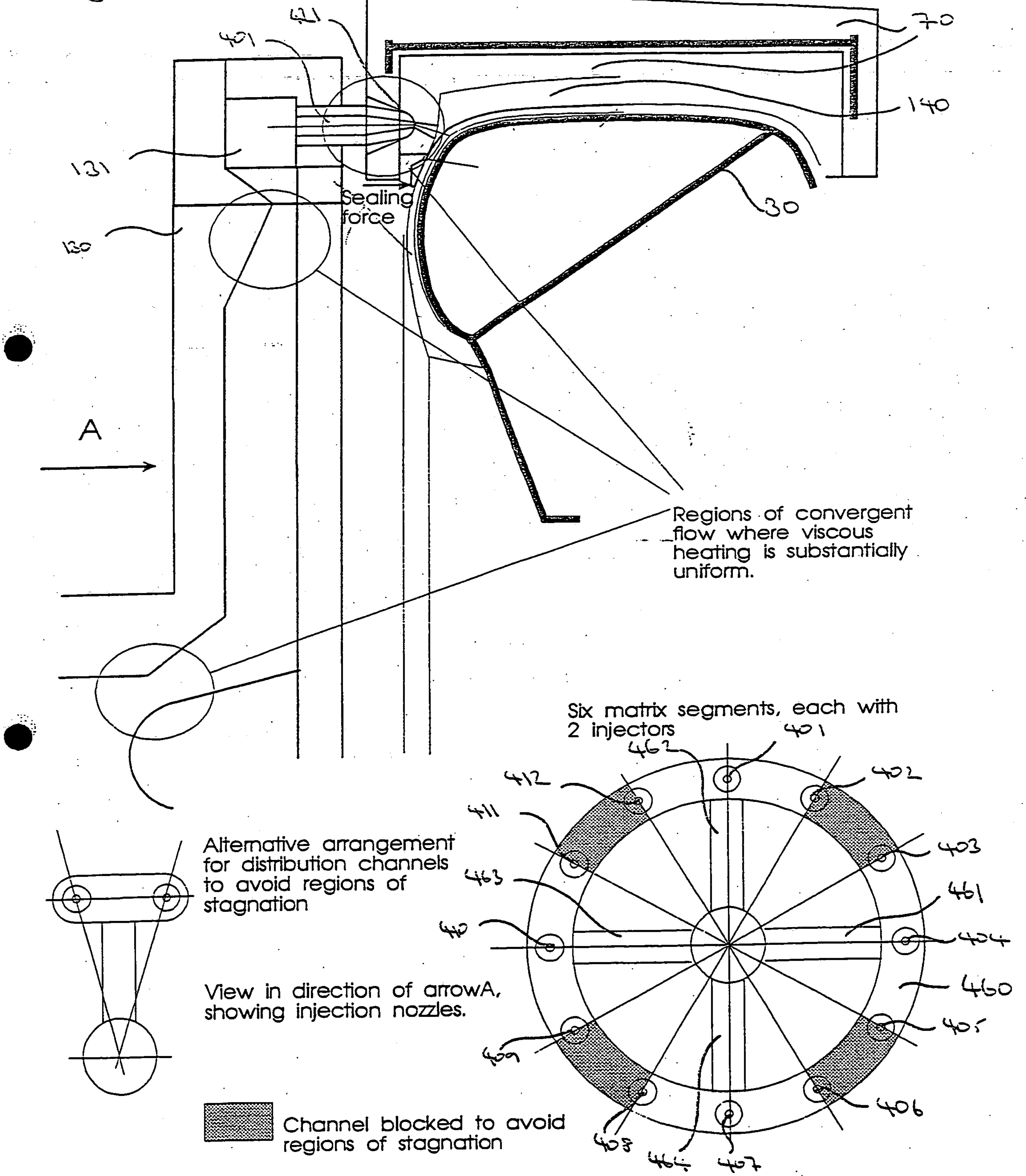
The main unknown and risk with this design is the integrity of the tread along "weld lines", since multiple injection port are used. However, the integrity should be as good as that of a normal joint formed in the uncured rubber and better than that in a pre-cured tread.



P. K. Freakley, Loughborough University, 5.3.98

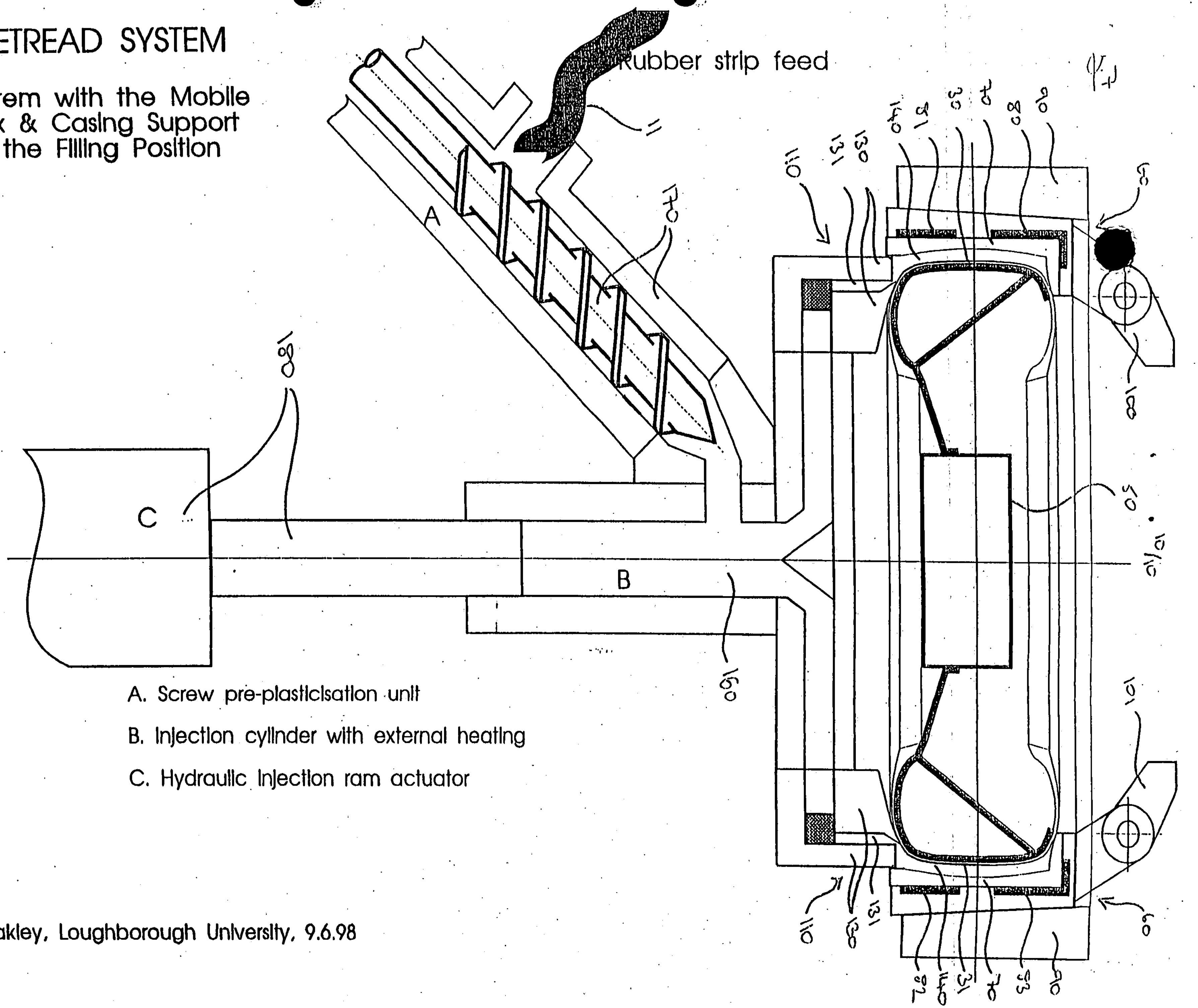
Detail of Injection Channels & Nozzles (ALT 1)

Fig. 6B



RuPEC RETREAD SYSTEM

Injection System with the Mobile Mould Matrix & Casing Support Assembly in the Filling Position



A. Screw pre-plasticisation unit

B. Injection cylinder with external heating

C. Hydraulic injection ram actuator

P. K. Freakley, Loughborough University, 9.6.98

McNeight & Lawrence
PCT/GB00/02828
17/08/00